Air Toxic Emissions from HD Diesel Vehicles Equipped with NOx and PM Retrofits

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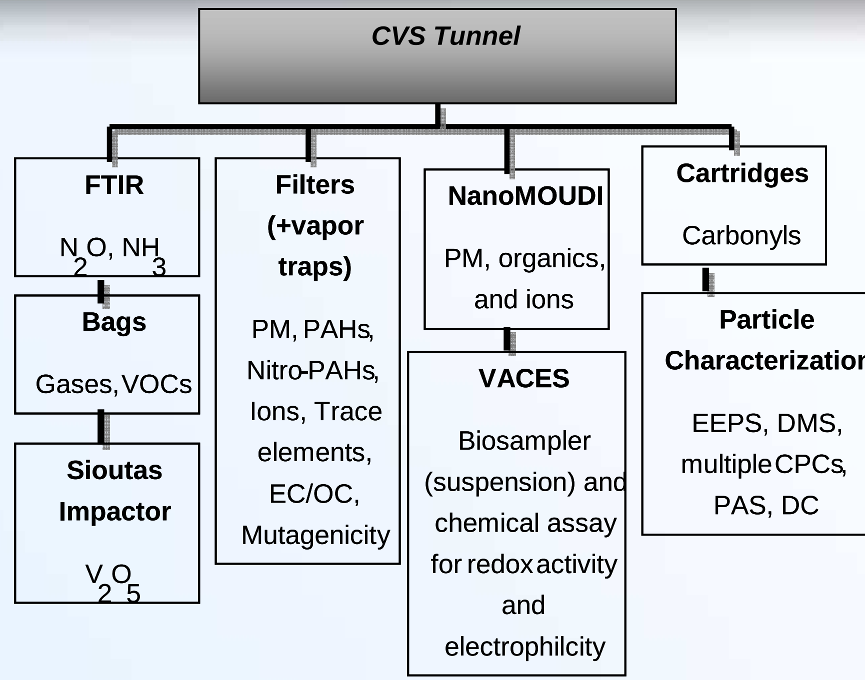
Overview

- Objectives
- Experimental Setup and Test Matrix
- Preliminary Results
  - Emissions of NMHC and BTEX
  - PM chemical speciation results
- Conclusions and next step

Objectives

- ARB needs data for 2010-like vehicles before they go into production. The retrofit systems of today are a glimpse into the production-ready OEM systems of the future (i.e., 2007/2010 systems)
- Assessing emission reduction and toxicity relevant to the older system

Experimental Setup

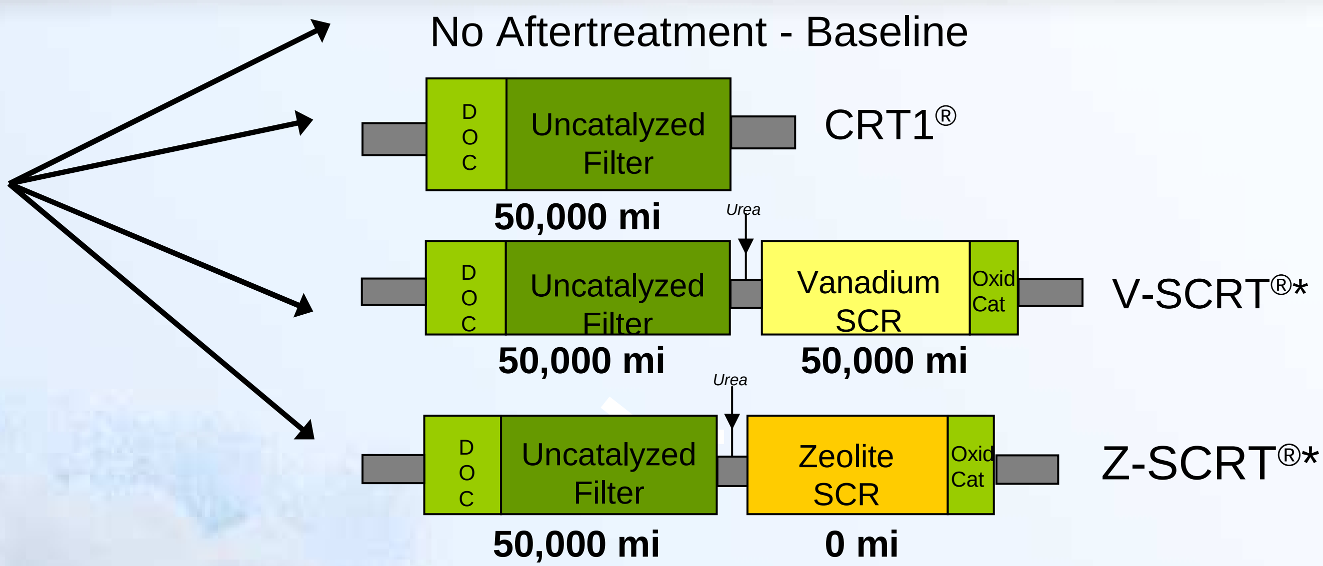


- **Test protocol follows 40 CFR Part 1065**
- **Driving Cycle: idling, transient (UDDS), and steady state (50mph cruising)**
- **Ultralow sulfur (<7ppm) fuel**

Sample Types	Filter Media	Flow rate range (lpm)	Method	Instrument
organic and elemental carbon	Quartz fiber	38-40	IMPROVE_A*, SOP MLD139	DRI Model 2001
Ionic species	PTFE filter	40-45	SOP MLD142	Dionex
PAH	TX40	75-80	SOP MLD144	ASE-GC/MS

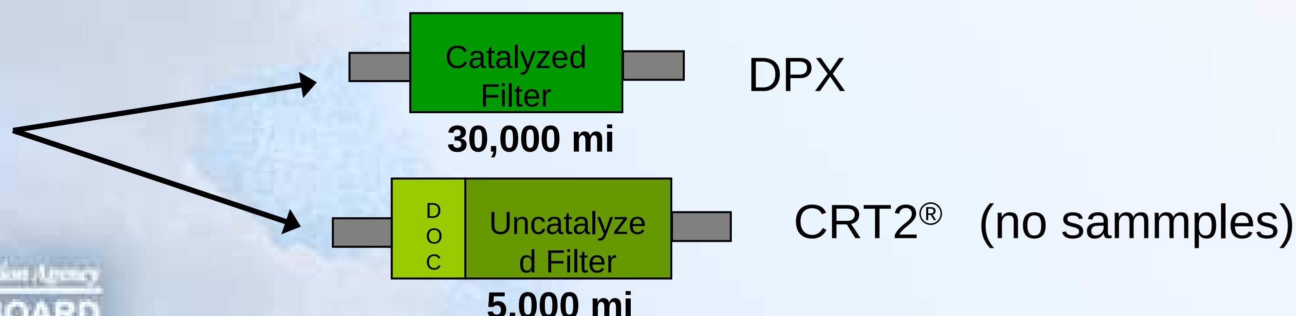
Test Matrix - 1/2
4 vehicles, 8 configurations

Veh#1 1998 Cummins Diesel 11L, 360,000 miles



*** SCRT® systems used in this project are development prototypes not commercial units.**

Veh#2 1999 International Diesel: 7.6L, 40,000 miles



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Test Matrix - 2/2
4 vehicles, 8 configurations

Veh#3 2003 Cummins Diesel 5.9L, 50,000 miles

Uncatalyzed Filter

31,000 mi

Horizon

Veh#4 2006 Cummins Diesel w/ Allison Hybrid drive; 5.9L, 1,000 miles18

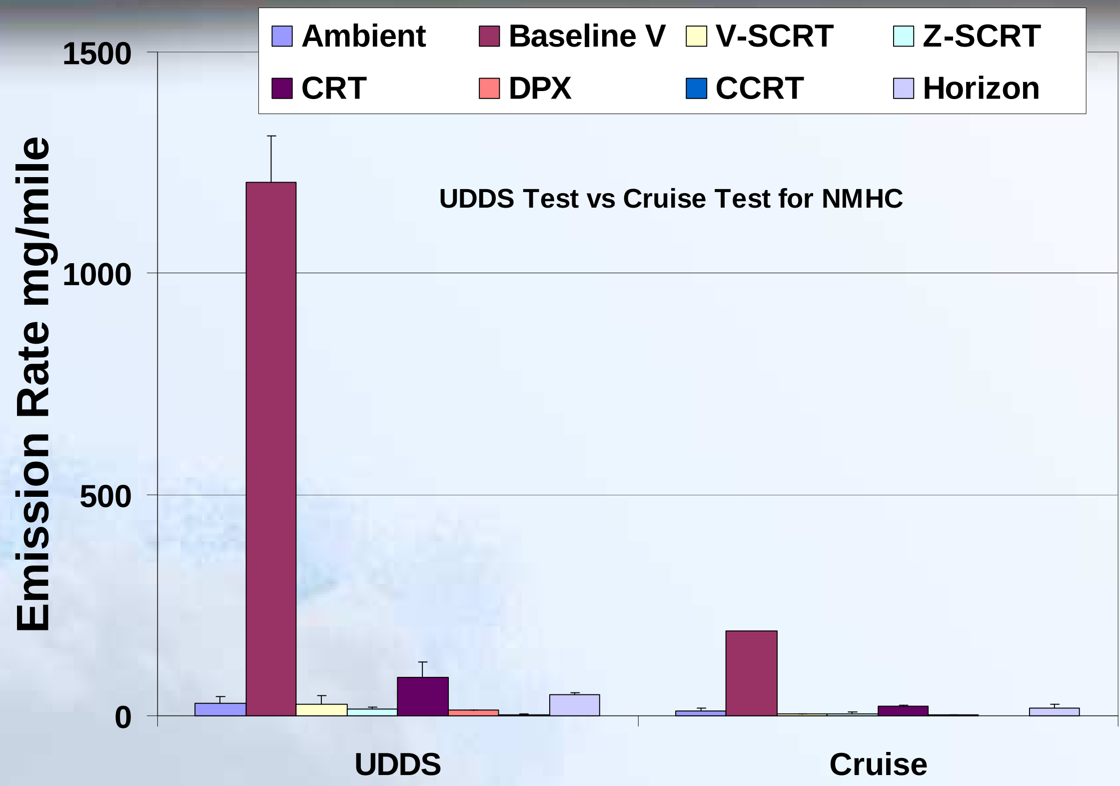
D O C | Catalyzed Filter

1,000 mi

CCRT®

Comparisons of emissions will focus on Vehicle #1 with three different aftertreatment technologies.

Preliminary Results: NMHC



The aftertreatment technologies can reduce more than 90% HMHC emissions for UDDS and Cruise cycles; but it is only 70% with Vanadium SCRT® for the idle mode

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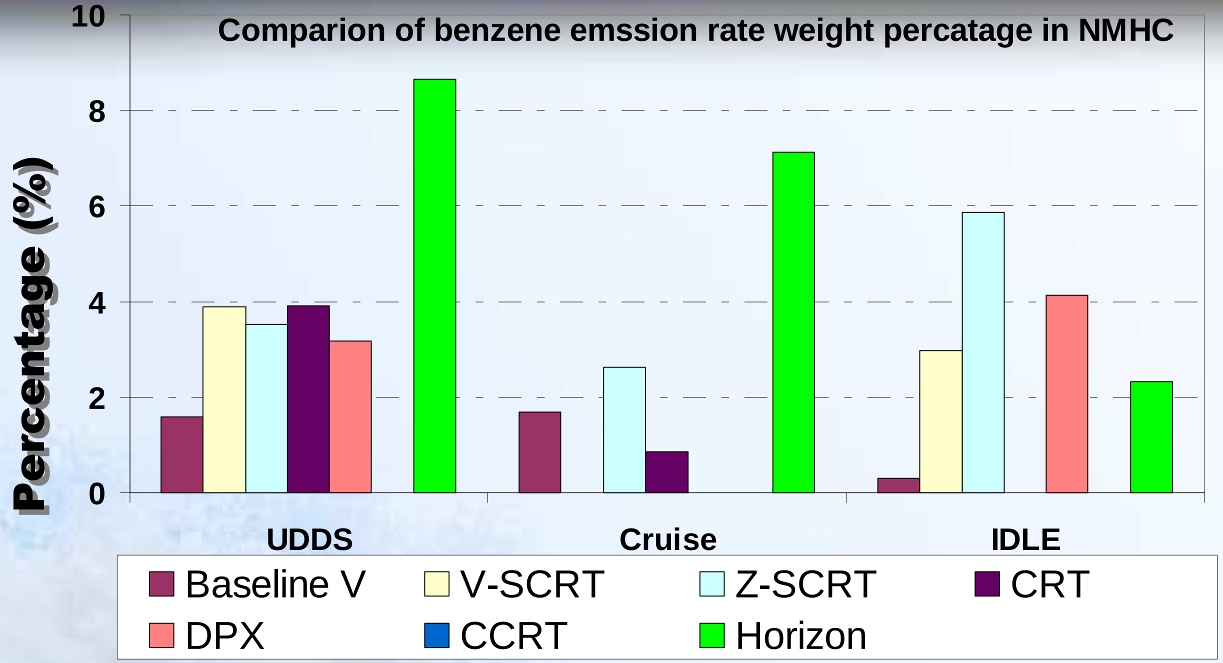
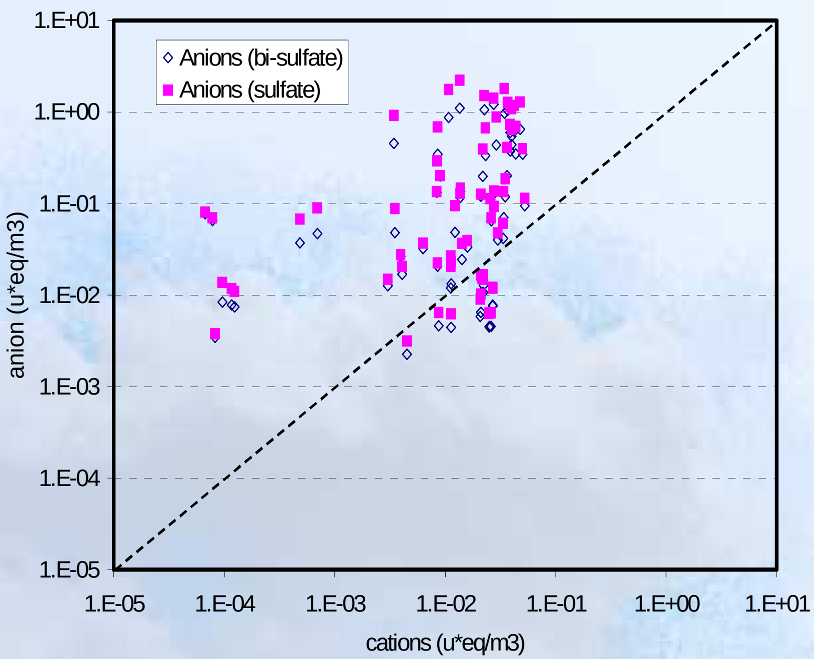
Preliminary Results: BTEX



- For transient and cruising cycles, high reductions of BTEX with Vanadium SCR® and Zeolite SCRT®.
- Observe some BTEX species to HMHC mass percentage with SCRT technologies were elevated during idle. Similar outcome was observed from the CNG bus in Phase I.

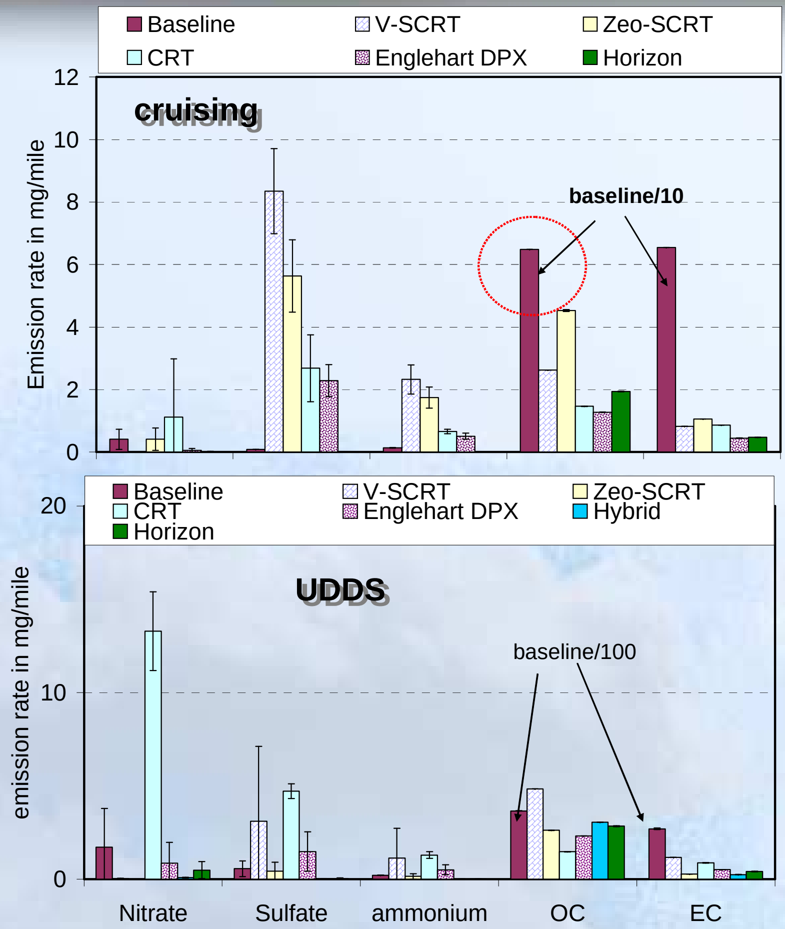
Quality Assurance for PM

Charge balance



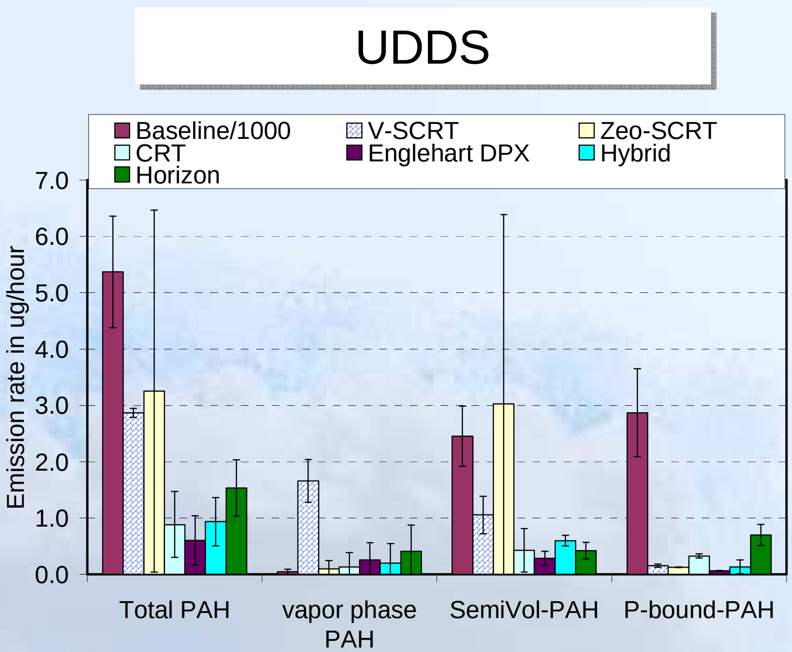
- High variation for gravimetric measurement due to low PM mass loading.
  - Challenging to compare mass concentrations and sum of chemical analysis (carbon analysis and ions)
- Significant sampling artifact observed, based on high OC1 and OC2 on the backup filter,
  - no systematic way of correcting the artifacts
- Dominant anions: sulfate and nitrate, cations: ammonium
- Charge balance (anions and cations)
  - More anions than cations; Suspect formation of nitric acid and sulfuric acid (Ristovski et al 2006, ES&T), not neutralized sulfate and nitrate

Preliminary Results: PM Speciation



- Emission rate:
  - Baseline: Transient >Cruising > Idling
  - Aftertreatment: Cruising>Transient >Idling
- Emission profiles:
  - Baseline: carbonaceous compounds
  - Aftertreatment: Sulfate and nitrate
- Emission reduction
  - With aftertreatment technologies, higher reduction efficiency for EC (soot) than OC: either less efficient to remove OC or due to sampling artifact
  - Increased sulfate and nitrate emission rates during cruising and UDDS test cycles.
  - Zeolite SCRT has the least emission reduction efficiency of organic carbon and nitrate.

Preliminary Results: PAHs on filters



- Definition in Phase I and categorize 23 PAHs to three groups: particle associated PAHs, semi-volatile PAHs, and volatile PAHs
- Total PAH on filters (V~10m^3)
  - With or without aftertreatment technologies: baseline: UDDS >cruising > idle
- General observation, total PAHs are enriched in
  - semi-volatile PAHs: fuoranthene, pyrene
  - particle bound PAH emissions: B(a)A, Chry, B(b)F, and B(k)F
- Aftertreatment technologies can reduce PAH emissions rates by at least three order of magnitude for semi-volatle and particle bound PAHs.

Conclusions

- The aftertreatment technologies can effectively reduce PM emissions.
- Analytical and statistical analysis:
  - Low emission level /concentrations for emissions with aftertreatment technologies (BTEX and PM)
  - Statistic analysis for chemical speciation data based on mass fraction (mass balance), due to the high uncertainly for low PM mass samples.
  - Challenging to assess the emissions variability (N=3)
  - Sampling artifact
- Need better understanding of catalyst characteristics/ roles in these aftertreatment technologies

Next Step

- On going effort:
  - Assessing intra-vehicle emission comparisons and those reported in mass/bhp-hr in the literature, with fuel density, break-specific fuel consumption, and fuel economy.
  - Elements, PAHs on PUF/XAD, biological toxicity results
  - Carbonyl and GHG results
  - Publications

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